PREVENTION AND TREATMENT OF HEAT AND COLD STRESS INJURIES

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Chapter 1

INTRODUCTION

1. Purpose

The purpose of this manual is to prevent heat and cold induced illness and injury among all personnel within the Department of the Navy.

2. Scope

This manual applies to all military and civilian personnel within the Department of the Navy.

3. Background

Personnel exposed to hot or cold environments risk the development of various injuries and illnesses. These include temporary or permanent disabilities and possible death. Even if no injury occurs, heat/cold exposure can lead to performance decrements. Inadequate training, insufficient equipment, and improper physical conditioning increase the susceptibility to heat/cold illness and injury. Nonacclimatized personnel are particularly susceptible to heat injury.

4. Responsibilities

a. All military and civilian personnel in supervisory positions and all medical personnel should become aware of the preventive measures and emergency treatments discussed in this manual.

b. All medical care providers should report to the Navy Environmental Health Center (NAVENVHLTHCEN), and the Navy Safety Center all injuries due to heat or cold stress using the Heat/Cold Injury Report Form found in Appendix A of this manual.

c. All medical treatment facilities should maintain an hourly log of the Wet Bulb Globe Index with the corresponding "flag condition" when the outside ambient (dry bulb) temperature is equal to or greater than 80 degrees Fahrenheit (°F).

Chapter 2

HEAT INJURY: ESSENTIAL PHYSIOLOGICAL PRINCIPLES

1. Sources of Heat

a. Total Heat Stress is the total heat load affecting an individual. It is the sum of the heat generated by the body plus the heat gained from the environment minus the heat that is lost to the environment. When working in hot environments, it becomes more difficult for the body to dissipate metabolic heat, and if the environmental heat is very high, body heat dissipation will be impossible.

b. Environmental Heat varies with changes in air temperature, air movement, water vapor pressure, and radiant heat. Each of these parameters is discussed in Chapter 3.

c. Metabolic Heat is generated by the body even at rest. As physical activity increases, the amount of metabolic heat generated also increases. Metabolic heat is often expressed as Kilocalories per square meter per hour (Kcal/m^2/hr). Resting muscles, which contribute about 45% of body weight, contribute 20% to 25% of the body generated heat. When expressed as heat produced per unit of body surface area, this value can be applied to all individuals. During exercise, muscles contribute a much higher percentage of the body generated heat. This heat must be dissipated to the environment to maintain normal body temperature.

2. Body Heat Regulation

a. Heat Strain is the body's response to the total heat stress. Heat generated by basal metabolism and muscular activity is dissipated from the body via convection, radiation, and evaporation.

b. Convection is the exchange of heat energy by molecules directly adjacent to each other. The rate of convective heat exchange between the body and the surrounding air is a function of the difference in temperature between the surrounding air and the skin temperature and the rate of air movement over the skin. As the environmental temperature decreases, the amount of heat loss by convection increases. In general, increasing air movement increases convective heat loss, however, excessive air velocity i.e., >1500 feet per minute (fpm), actually produces heat from kinetic energy. Also when air temperature exceeds skin temperature or is greater than 95 °F, air velocity should not exceed 300 fpm.

c. Evaporation of water produces cooling. Thus the evaporation of sweat from the skin results in heat loss from the body. The maximum heat loss from evaporation is a function of the rate of air motion over the skin and the water vapor pressure difference between the surrounding air and the wet skin. In hot environments, the amount of heat loss achievable via sweating is the major determinant of the body's ability to maintain a normal core temperature. As humidity increases, the rate of evaporation decreases. In very humid environments, evaporative cooling is greatly curtailed, and, depending on the amount of physical activity, body core temperature may rise at relatively cool environmental temperatures. Impermeable clothing creates a barrier to evaporation of sweat, and thus greatly hinders the body's ability to dissipate heat. As qualified above, when the rate of air movement over the skin increases, the rate of evaporation also increases. This is why fanning has a cooling effect.

Chapter 3

MEASUREMENT OF HEAT STRESS

1. Environmental Measurements

Reference (a) discusses in detail environmental measures of heat stress. Personnel responsible for monitoring environmental working conditions should be familiar with this reference. All medical treatment facilities must maintain an hourly log of the WBGT Index beginning at 0800 and ending at 1700 on days when the ambient temperature is expected to exceed 80°F. The log must be kept on file for one year. Reference (b) contains an example of a log for recording the WBGT Index. Brief definitions of important environmental measurements follow:

a. The Dry-Bulb Temperature is commonly used to indicate the air temperature. Strictly defined it is the temperature taken using a standard alcohol-in-glass or mercury-in-glass thermometer with the bulb dry and shielded from radiant heat.

b. The Aspirated Wet-Bulb Temperature is measured by fitting a wet wick over the bulb of a standard thermometer and moving air over the wet wick by a fan, a motorized psychrometer or sling psychrometer. For a true wet-bulb reading, the air flow should be at least 250 feet per minute (fpm) but less than 1500 fpm, with the bulb shielded from radiant heat.

c. The Globe Temperature integrates radiant heat exchange and convective heating or cooling into a single value. The Vernon Globe Thermometer is the standard instrument for measuring the globe temperature. The Vernon Globe consists of a six inch hollow copper sphere with 0.022 inch thick walls painted flat (matte) black on the outside and containing an unshielded dry-bulb thermometer or its equivalent in the center of the sphere. Smaller globe thermometers have been developed, but few can be considered equivalent to the Vernon Globe.

d. Wet-Bulb Globe Temperature (WBGT) Index takes into account air temperature, humidity, radiant heat, and air movement. The WBGT index can be calculated using the following equation:

$$\text{WBGT} = 0.7 \text{ Aspirated Wet-Bulb} + 0.2 \text{ Matte Black Globe} + 0.1 \text{ Shielded Dry Bulb}$$

2. Environmental Heat Measurement Devices

a. The Heat Stress Monitor, (Model 960), measures the shielded dry-bulb, aspirated wet-bulb, and globe temperatures. It also calculates the WBGT index and the stay times using physiological heat exposure limit (PHEL) curves. It is a lightweight, self-contained, unit equipped with a rechargeable power supply. Reference (c) describes the operation and maintenance of the Heat Stress Monitor, Model 960.

b. The Navy Heat Stress Meter, (Model 220), measures the shielded dry-bulb, aspirated wet-bulb, globe temperatures and computes the WBGT index. It is a lightweight, self-contained unit equipped with a rechargeable power supply. The use and maintenance of the meter is demonstrated in the Navy educational film "Care and Use of the Heat Stress Meter" (35335).

c. A WBGT field kit may be set up as demonstrated in reference (b) if one of the above authorized heat stress meters is unavailable.

3. Physiological Monitoring

Physiological monitoring is recommended for initial heat stress evaluations of a workplace or job where excessive environmental heat or excessive metabolic heat generation may be anticipated and when metabolic rates and stay times can not be estimated from existing tables. Reference (d) contains a simple way to assess if environmental temperatures and/or metabolic heat production are placing workers at an unacceptable risk of heat illness.

Chapter 4

RECOGNITION, EMERGENCY FIELD TREATMENT, AND DISPOSITION OF HEAT INJURY

1. Recognition and Emergency Field Treatment

a. Heat Stress is excessive when the body's capability to regulate its temperature is exceeded. As the body's temperature increases beyond the range of normal, symptoms of fatigue, headache, weakness, nausea, and vomiting can be expected to follow. Mental and physical performance may be compromised even before symptoms are apparent. Continued heat stress will lead to heat exhaustion or heat stroke. In order to prevent this sequence of events from occurring, all personnel must be familiar with the signs and symptoms of heat strain.

b. Heat Rash, also known as prickly heat, appears as red papules, usually in areas where the clothing is restrictive, and gives rise to a prickling sensation, especially as sweating increases. Heat rash may be more than an annoyance. It may interfere with sleep resulting in sleep deprivation which increases the risk of heat exhaustion and heat stroke. Heat rash impairs sweating and thus interferes with evaporative cooling. Treatment is directed at keeping the skin as cool and dry as possible. The wearing of impermeable clothing can be expected to aggravate heat rashes. It is unnecessary to report heat rash on the Heat/Cold Injury Form.

c. Heat Cramps may occur without associated heat exhaustion in individuals with a normal body temperature. They are usually associated with inadequate salt replacement. Heat cramps differ from exertional muscle cramps in that the entire muscle is not involved. Heat cramps appear to wander as individual muscle bundles contract. Heat cramps are observed primarily in unacclimated individuals and usually appear after the cessation of activity. Exertion induced muscle cramps are more apt to occur during exercise. Muscular soreness which may be felt after heat cramps must be differentiated from rhabdomyolysis. In contrast to heat cramps, the onset of rhabdomyolysis is usually delayed one to two days after muscle injury with associated dark amber urine and persistent localized muscular tenderness. The muscular soreness associated with rhabdomyolysis is much more severe than the soreness experienced following heat cramps.

d. Heat syncope is the occurrence of fainting when standing in a hot environment and is a result of postural hypotension (low blood pressure related to the upright position). The drop in blood pressure results from the shunting of blood to the cutaneous vasculature and the pooling of blood in the lower extremities. The resulting unconsciousness is transient and without lasting effect unless there is an injury resulting from the fall. If standing is required in hot environments where injury from a fall is likely, heat syncope should be considered a significant safety concern. Allowing individuals to move about will help prevent heat syncope. Providing places to sit (e.g. a chair or stool), insuring railings are present at proper heights, etc. will decrease the risk of injury if fainting should occur.

(1) Pregnancy increases susceptibility to heat syncope. In hot environments, pregnant women should not be required to remain standing at attention. Although the individual suffering from heat syncope will regain consciousness almost immediately upon lying down, medical evaluation should be obtained to rule out other causes of syncope.

(2) When filling out the Heat/Cold Stress Injury Form, all heat syncope cases should be checked off as heat exhaustion, due to the difficulty in clinically differentiating the difference between heat syncope and heat exhaustion.

e. Heat Edema refers to swelling of the hands and feet associated with heat exposure. It is not a sign of underlying cardiac or hepatic disease. Elevation of the legs will decrease the leg swelling. Heat edema is uncomfortable and may make marching impossible due to tight fitting footwear. Heat edema is common in pregnancy, especially in nonacclimatized individuals. Heat edema does not indicate excessive water intake.

f. Heat Exhaustion is a multisystem disorder resulting from an increase in body temperature and/or dehydration with or without salt depletion. If regular meals are consumed, salt depletion is very unlikely, especially in acclimatized individuals. Heat exhaustion may occur with heat exposure associated with physical exertion in the absence of dehydration.

(1) Signs and symptoms of heat exhaustion include profuse or decreased sweating. Decreased blood pressure from volume depletion produces signs and symptoms of shock, e.g. rapid pulse, positive tilt test, faintness, confusion, and even unconsciousness. Other signs and symptoms of heat exhaustion include headache, nausea, vomiting, loss of appetite, and incoordination. Rectal temperature is usually elevated, generally up to about 102°F.

(2) Anyone who experiences even mild symptoms of heat exhaustion should be moved to a cool place to rest. In field situations, move heat stress casualties to a shaded area, have them lie down and elevate their legs. Sprinkle or spray victims with water, and fan them to facilitate evaporative cooling. Sips of water should be provided to fully conscious individuals. Medical evaluation should be obtained. **Rectal temperature should be obtained immediately.** If the rectal temperature is over 104°F the victim should be considered to have heat stroke. Cooling should continue until the rectal temperature is less than 102°F, at which time cooling measures should be ceased so as to prevent hypothermia. Recovery from heat exhaustion, generally takes at least 48 hours.

g. Heat Stroke occurs when the thermoregulatory system collapses. **Rectal temperature should be obtained immediately.** If the rectal temperature is over 104°F the victim should be considered to have heat stroke.

(1) Heat Stroke is a **MEDICAL EMERGENCY!** Rapid treatment is imperative as the risk of death is related to the magnitude and duration of the increased body temperature. The victim may progress from normal homeostasis through heat exhaustion to heat stroke. However, heat stroke may occur suddenly with convulsions, delirium, vomiting, and unconsciousness. Bleeding may be seen from the nose or gums. Serum enzymes will be elevated. Involvement of the central nervous system, hematologic and urinary systems are usually associated with severe cases. Elevation of the serum enzymes usually occurs 24 hours after heat stroke. Therefore, **all heat injured personnel with rectal temperatures greater than 104°F should have their serum SGOT levels obtained 24 hours following the initial heat stress injury.** Generally, the higher the SGOT the greater the damage to the central nervous system, kidneys and liver.

(2) In the past, a heat stroke victim was described as always having hot, dry skin as opposed to the moist clammy skin of a heat exhaustion victim. It has been found that although the skin may be hot and dry, just as often it may be moist from sweat. Therefore, upon initial evaluation, the skin can not be the differentiating factor in deciding on the degree of the heat injury. Only rectal temperature can initially differentiate between heat stroke and heat exhaustion.

(3) Individuals suspected of suffering from heat stroke should be taken to an emergency medical treatment facility immediately. While waiting for transport, if possible, the victim should be immersed in cold water. If this is not possible, sprinkle or spray with cold water, and fan. Efforts to cool the victim should continue while transporting to the emergency room. Cooling should continue until the rectal temperature is less than 102°F, at which time cooling measures should cease so as to prevent hypothermia. Intravenous fluids should be given as early as possible. Never attempt to give oral fluids to an unconscious or semiconscious person.

2. Disposition

After initial recovery, heat injured victims should be returned to light duty but not restricted to air conditioned spaces. Heat injured victims should be restricted from performing heavy labor or exercise in the heat until their SGOT levels return to within normal limits. After the SGOT returns to within normal limits, heat injured victims should be reacclimated to the heat under medical supervision with exercise or labor of gradually increasing intensity before being released to full duty. The length of time for reacclimatization is dependent upon the severity of the heat stress injury and the response of the injured person. **Under no circumstances should a heat stroke victim be placed on full duty with less than seven days of reacclimatization after normalization of the serum SGOT.**

Chapter 5

PREVENTIVE MEASURES FOR HEAT INJURY

1. Acclimatization

Acclimatization refers to the physiologic adaptation which occurs over a succession of days in individuals exposed to environmental heat stress which results in reducing the strain caused by the heat stress. For example, acclimatization results in increased and more efficient sweating. That is, the sweat rate increases while the amount of sodium lost per milliliter of sweat decreases. Sweating also begins at a lower core body temperature after acclimatization. Acclimatization also results in lowered cardiovascular strain manifested primarily by a lower heart rate.

a. Although good physical conditioning may increase the rate of acclimatization, exercise training in cool weather is not a substitute for heat acclimatization. Heat acclimatization will decrease after a few days away from the heat exposure, therefore personnel returning from leave in a cooler environment will require some degree of reacclimatization.

b. Regular exercise of gradually increasing intensity and duration in the heat is the most effective method of acclimatization. However, some degree of acclimatization will occur in individuals engaging in little activity. Acclimatization can be accomplished with about 100 minutes of heat exposure per day. A significant degree of acclimatization can be expected in 7-10 days, however, maximum heat tolerance should not be expected for several more days.

c. It should always be kept in mind that the benefits of heat acclimatization can be decreased or nullified by such things as sleep loss, infection, dehydration, and salt depletion.

d. The effects of pregnancy on the rate of heat acclimatization are not known, therefore a more gradual approach to acclimatization in coordination with the responsible obstetrician and occupational medicine physician is recommended.

2. Water Requirements

Hypohydration (insufficient water intake) is much more likely to lead to heat illness than hyponatremia (low plasma sodium levels). Working in hot environments may result in the production of 6-8 liters of sweat during the work day. The normal thirst mechanism is not sensitive enough to keep up with this fluid loss rate.

a. The need for increased water intake can not be overstated. Adequate water intake is essential in preventing heat illness. Thirst (or the lack of it) is not an accurate indicator of fluid needs. Tolerance to dehydration cannot be developed.

b. In order for workers or troops to consume enough water to replace the large quantities lost in sweat, a definite planned effort must be executed. Supervisors and officers in charge should monitor water intake. Simply telling personnel to drink plenty of fluids in not sufficient. Water must be available and close by. It also should be palatable. Water temperature should be 50-60°F if at all possible. During moderate activity, in moderately hot conditions, at least one pint of water per hour is needed. Small quantities should be consumed frequently, i.e. about 6 ounces or a medium glass full about every 20 minutes.

3. Sodium Requirements

The normal American diet provides about 8-15 grams of salt a day. Military rations are usually heavily salted and may provide a daily salt intake of about 25 grams. Except for non-acclimatized individuals on low salt diets and/or diuretics, salt depletion from working in hot environments usually does not occur. Salt loss in sweat ranges from about 4 gram/liter for the nonacclimatized individual to 1 gram/liter for the acclimatized. Recommending liberal use of the salt shaker at meal time during the first 3 days of acclimatization (except of course for those on restricted salt diets) is all the sodium supplementation that should be needed. Carefully planned heat acclimatization will reduce or eliminate any need for salt supplementation. Salt tablets should not be used unless prescribed by a physician.

4. Medical Surveillance and Pre-placement Screening

Reference (e) requires appropriate medical surveillance and screening of employees who are or will be working in hot environments. Reference (f) includes a program for heat stress medical surveillance. Several medical and physiological conditions can make adjustment to hot environments more difficult including the following:

a. Sleep deprivation

b. Alcohol abuse (One of the effects of alcohol is to act as a diuretic)

c. Many medications including diuretics and cold remedies

d. Obesity

e. Acute and chronic diseases such as high blood pressure, heart disease, viral infections, and gastroenteritis

f. Prior history of heat exhaustion/stroke

g. Pregnancy

h. Age over 40

5. Engineering and Administrative Controls

The best way to prevent heat illness from occurring in a hot environment, is to make the work environment cooler. In outdoor situations for troop activities, this may be accomplished by scheduling activities in the cooler times of the day. However it should be kept in mind, that very early starting times have been associated with sleep deprivation, and that humidity tends to be higher in the early morning hours. Indoor environments may be alterable through the use of air conditioning or increased ventilation (assuming cooler air is available from the outside). In addition, providing reflective shields to deflect radiant heat, insulating hot surfaces, and decreasing water vapor pressure, e.g. by sealing steam leaks, keeping floors dry, etc. may also alter indoor temperature. With respect to decreasing convective heat transfer, increasing the air speed over the worker will increase the heat exchange between the skin surface and the air unless the air temperature exceeds the skin temperature. Also, increasing air speeds above 300 fpm may actually have a warming effect. Cooling by evaporation of sweat can also be facilitated by increasing air movement over the worker. Of course increasing the air speed will have no effect on workers wearing vapor impermeable clothing. The expertise of the cognizant industrial hygiene personnel may be called upon to assess the degree of heat stress imposed by the work environment and to make recommendations for reducing environmental heat exposure.

6. Limitations of activity

a. Active duty limitations: Reference (a) recommends work limitations using the WBGT Index and physiological heat exposure limit (PHEL) curves. These limitations are designed for work in industrial settings. Limitations for exercise and for activities in the field should use the Wet-Bulb GLobe Temperature (WBGT) with the flag system as outlined below and in reference (b).

(1) White flag. When the WBGT index is less than 80, extremely intense physical exertion may precipitate heat exhaustion or heat stroke, therefore, caution will be taken. A white flag is flown at this condition level.

(2) Green flag. When the WBGT index is between 80 and 84.9, discretion is required in planning heavy exercise for unacclimatized personnel. This is a marginal heat stress limit for all personnel. A green flag is flown at this condition level.

(3) Yellow flag. When the WBGT index is between 85 and 87.9, strenuous exercise and activity will be curtailed for new and unacclimatized personnel during the first 3 weeks of heat exposure. Outdoor classes in the sun will be avoided when the WBGT index exceeds 85. A yellow (amber) flag is flown at this condition level.

(4) Red flag. When the WBGT index is between 88 and 89.9, strenuous exercise

will be curtailed for all personnel with less than 12 weeks of living and working in hot weather. A red flag is flown at this condition level.

(5) Black flag. When the WBGT index is 90 or above, strenuous, nonessential outdoor physical activity will be suspended for all personnel. Essential activities are defined as those activities associated with scheduled exercises or other major training evolutions where disruption would cause undue burden on personnel or resources, be excessively expensive, or significantly reduce a unit's combat readiness. Essential outdoor physical activity will be conducted at a level that is commensurate with personnel acclimatization as determined by the unit's commanding officer in coordination with the unit's medical officer or medical personnel. All efforts should be made to reschedule these activities during cooler periods of the day. A black flag is flown at this condition level.

b. Civilian limitations. References (e) and (g) are to be used for heat stress management of civilian employees. Tables 5.1, 5.2, and 5.3 should be used to determine work rest regimens for civilian employees. The Threshold Limit Values (TLVs) in the tables are based on the assumption that nearly all acclimatized, fully clothed workers with adequate water and salt intake are able to function effectively under the given working conditions without exceeding a deep body temperature of 38°C. They are also based on the assumption that the WBGT value of the resting place is the same or very close to that of the workplace.

(1) Tables 5.1 and 5.2 are to be used to estimate the overall workload of the worker. Then the workload category is estimated and the appropriate work/rest regimen is determined using Table 5.3. Work load categories found in Table 5.3 are as follows:

(a) light work (up to 200 Kcal/hr): e.g., sitting or standing to control machines, performing light hand or arm work,

(b) moderate work (200-350 Kcal/hr): e.g., walking about with moderate lifting and pushing, or

(c) heavy work (350-500 Kcal/hr): e.g., pick and shovel work.

Table 5.1

Assessment of Work Load

A.	Body Position and Movement	Kcal	
	Sitting	18	
	Standing	36	
	Walking	120-180	
	Walking uphill	add 48 for every one meter rise	
B.	Type of Work	Kcal/hr	Range Kcall/hr
	Hand work		
	Light	24	12-72
	Heavy	54	
	Work one arm		
	Light	60	42-150
	Heavy	108	
	Work both arms		
	Light	90	60-210
	Heavy	150	
	Work whole body		
	Light	210	150-540
	Moderate	300	
	Heavy	420	
	Very heavy	540	
Basal Metabolism		60	

Source: Reference (g)

For "standard" worker of 70 kg body weight (154 lbs.) and 1.8 square meter body surface.

Table 5.2

Activity Examples

--**Light hand work:** writing, hand knitting

--**Heavy hand work:** typewriting

--**Heavy work with one arm:** hammering in nails (shoemaker)

--**Light work two arms:** filing metal, planing wood, raking a garden

--**Moderate work with the body:** cleaning a floor, beating a carpet

--**Heavy work with the body:** railroad track laying, digging

Sample Calculation:

Assembly line work using a heavy hand tool.

A. Walking along	2.0 kcal/min
B. Intermediate value between heavy work with two arms and light work with the body	3.0 kcal/min
C. Add for basal metabolism	1.0 kcal/min
Total:	6.0 kcal/min

Source: Reference (g)

Table 5.3

Permissible Heat Exposure Threshold Limit Values

Work/Rest Regimen	Work Load: Light	Moderate	Heavy
Continuous Work	86	80	77
75% Work, 25% Rest, Each Hour	87	82.4	78.6
50% Work, 50% Rest, Each Hour	89	84.9	82.2
25% Work, 75% Rest, Each Hour	90	88	86
Values are in Fahrenheit, WBGT			

Source: Reference (g)

(2) When a worker is not continuously exposed in a single hot area but moves between two or more areas having different levels of environmental heat, or when the environmental heat varies substantially at a single hot area, environmental heat exposure should be measured for each area and for each level of environmental heat to which employees are exposed. Also, where the WBGT of the work area is different from that of the rest area, the WBGT of the rest area should be measured.

(3) Combining all WBGTs and metabolic rates into the formulas found in reference (g), TLVs can be calculated and followed. In cases where it is too difficult for the supervisor to calculate TLVs, the assistance of an Industrial Hygienist should be obtained.

c. Clothing factors are of concern for both military and civilian workers.

(1) Recommended stay times in hot environments assume work clothing is permeable and consists of not more than the customary long-sleeved work shirt and trousers (or equivalent). Clothing which lowers air and vapor permeability will interfere with body cooling, decreasing heat tolerance. In general, as the thickness and air/vapor impermeability of clothing increases, interference with convective, radiative, and evaporative heat exchange increases.

(2) Vapor impermeable clothing such as full mission oriented protective posture (MOPP 4) suits pose significant problems with respect to heat stress. Even in cool temperatures (50-70°F), personnel wearing such clothing and performing heavy work will require more frequent rest periods out of the impermeable clothing in order to dissipate metabolic heat. Workers wearing semi-permeable or impermeable clothing should be monitored when the ambient (dry bulb) temperature is above 70°F. Monitoring may include pulse rates, body temperatures, observations and verbal communication with the worker. Personnel in MOPP 4 should not be expected to perform heavy work in hot temperatures (above 85°F) unless absolutely necessitated by operational requirements.

Chapter 6

ESSENTIAL INFORMATION REGARDING PREVENTION OF COLD CASUALTIES

1. Body Heat and Environment

Body heat is regulated by a complex interaction of factors including temperature, air movement, humidity, and radiant heat, as well as the individual's physiologic and behavioral responses. Changes in body temperature are the result of a balance between heat production and heat losses. The human body operates at peak efficiency within a narrow core temperature range around 98.6°F (37°C), while the shell extremity temperature may fluctuate safely through a much wider range. The thermostat that controls body temperature is located in a part of the brain called the hypothalamus. Internal body temperature is regulated by control of blood flow from sites of heat production to the body surface. Body heat is produced by combustion of carbohydrates, fats, and proteins. If the heat of the body is to remain constant, the heat produced and the heat gained must equal the heat lost. Metabolic heat production, plus or minus radiant, conductive, and convective heat exchange, minus evaporative heat loss equals the storage of heat in the body.

2. Nature of Cold Injury

a. Cold injury and illnesses have a worldwide distribution. The physiologic effects of cold exposure include mechanisms designed to conserve energy and increase body heat production. These include superficial constriction of the blood vessels, increased concentration of the blood, increased muscular activity (shivering), and increased oxygen consumption. If body temperature cannot be sustained, various degrees of hypothermia and surface tissue injuries develop. The ability of the body to respond to cold is modified by factors such as age; fatigue; other injuries and illnesses; history of previous cold injury; discipline; training and experience; race and area of origin; drugs and medications, including alcohol and tobacco; activity; psycho-social factors; and the state of hydration. Heat loss is strongly affected by the wind chill factor, which is a measure of the combined effects of wind and temperature, and by conductive loss due to immersion in cold water.

b. The types of cold injuries are nonfreezing and freezing. Nonfreezing injuries, which occur with environmental temperatures above freezing, are chilblains, immersion injuries, and hypothermia,. Freezing injuries (frostbite) occur when environmental temperatures fall below freezing. Other common conditions that may occur during cold weather operations are acute mountain sickness, carbon monoxide poisoning, snow blindness, and constipation.

c. Nonfreezing Injuries:

(1) Chilblains (Pernio) is a superficial tissue injury which occurs after prolonged or intermittent exposure to low but nonfreezing temperatures and high humidity. Chilblains are characterized by initial pallor. After rewarming there may be erythema, edema, and itching.

(2) Immersion injuries result from prolonged exposure to cold water, usually 12 hours or longer at temperatures of 50-70°F (10-21°C) or for shorter periods at or near 32°F (0°C). Trenchfoot is an immersion injury seen in trench warfare where mobility is limited and dry boots and socks are unobtainable. The injured part is cold, swollen, waxy-white, with cyanotic burgundy-to-blue splotches, the skin is anesthetic and deep musculoskeletal sensation is lost.

(3) Hypothermia is a reduction of the body's core temperature below its normal level (98.6°F or 37°C), which results in a progressive deterioration in cerebral, musculoskeletal, and cardiac functions. Three degrees of severity are recognized and defined by core temperatures:

(a) Mild Hypothermia 95-89.6°F, initially characterized by violent shivering followed by virtual cessation of effective muscular activity, disorientation and disinterest in surroundings

(b) Moderate Hypothermia 89.59-78.8°F, with cardiac irregularities occurring at about 86°F (30°C) and corneal reflexes absent below 82.4°F (28°C) .

(c) Severe Hypothermia occurs at core temperatures 78.79°F and lower, and with ventricular fibrillation a paramount risk below 80.6°F (27°C) and the patient may appear clinically dead. Because patients have been successfully resuscitated at core temperature of 64°F (18°C), the axiom to be remembered is, "No one is dead until he is warm and dead."

d. Freezing injuries and frostbite result from exposure to temperatures below freezing. The speed of onset, depth, and severity of injury depend on temperature, windchill, and the duration of exposure. Cellular injury and death occur from cellular trauma due to ice crystal formation and from complex vascular reactions occurring in cold exposure. Superficial frostbite involves only the skin or the tissue immediately beneath it, while deep frostbite also affects the deep tissue beneath (including the bone). If the tissue has frozen, it appears "dead white" and is hard or even brittle. Differentiation of the types and severity of injury may be difficult even after rewarming has occurred. Definitive classification of severity is possible only in retrospect, after the case is completed.

(1) First degree frostbite is similar to mild chilblain with hyperemia, mild itching, and edema: no blistering or peeling of skin occurs.

(2) Second degree frostbite is characterized by blistering and desquamation.

(3) Third degree frostbite is associated with necrosis of skin and subcutaneous tissue with ulceration.

(4) Fourth degree frostbite includes destruction of connective tissues and bone, accompanied by gangrene. Secondary infections and the sequelae noted for nonfreezing injuries are not infrequent, particularly if there is a history of freeze-thaw-refreeze.

3. Susceptibility of Personnel

a. Acclimatization for 1-4 weeks enables the body's physiologic mechanisms to adapt to the cold environment. The cold adapted person conserves heat better, shivers less, and functions more efficiently in the cold.

b. Age is not a significant problem within the usual range of combat personnel, although very young children and the elderly are more susceptible to cold injury.

c. Grade or rate is significantly associated with cold injury in that front line riflemen have a higher risk of immersion foot and frostbite than higher ranks.

d. Previous cold injury produces susceptibility to recurrent injury.

e. Fatigue can cause carelessness and increases the risk of cold injury.

f. Other injuries or illnesses increase the risk of occurrence and the severity of cold injury, including injuries that cause tissue damage, blood loss and hypovolemia, and febrile illnesses that interfere with normal temperature regulating mechanism and predispose to hypothermia.

g. Discipline, training, and experience are important factors in prevention of cold injury. Poorly motivated, negative individuals tend to be less active, pay less attention to personal care needs, and are more susceptible to cold injuries.

h. Race and Area Origin. Although the mechanisms are unclear, Caucasians from U.S. climates with minimum January temperatures above 20°F (-7°C) and American Blacks appear to share an increased hazard of developing cold injury.

i. Activity. Too great or too little activity may contribute to cold injury. Over activity may cause loss of body heat through perspiration. Immobility causes decreased heat production.

j. Drugs and Medications. Drugs which affect peripheral circulation or perspiration modify the response to cold, and must be used with caution. Phenothiazides and barbiturates can modify shivering and states of awareness, and predispose to cold injury. The use of tobacco is discouraged during cold weather operations because of its vasoconstricting effect, and is forbidden in the treatment of frostbite. Alcohol has more disadvantages than advantages, because its vasodilatory effect robs the body's core of an essential protective mechanism and produces a detrimental distortion of judgement.

k. Nutrition. Starvation or near starvation diets predispose to cold injury.

l. Water deprivation will cause more problems than lack of food, causing an increased risk of frostbite and impairment of judgment. It may lead to severe gastrointestinal problems and hypothermia.

4. Preventive Measures.

Cold injuries are avoidable by proper use of preventive measures that are inspected and enforced by officers and noncommissioned officers.

a. Windchill is defined as the number of calories lost during 1 hour from a square meter of a surface kept at 91.4°F (33°C). A temperature of 20°F (-7°C) and wind speed of 45 miles per hour produce the same effect as a temperature of -20°F (-29°C) and a wind speed of 4 miles per hour, a loss of 1400 kilo calories per hour. Exposed flesh may freeze in 1 minute at a temperature of 15°F (-9°C) at wind velocity of 25 miles per hour. Helicopter downwash converts a calm day into a windy one, and can cause instant frostbite. All individuals going to the cold environment should be aware of the following windchill chart and use protective measures that are appropriate for the equivalent temperature:

Table 6.1

WINDCHILL CHART

Estimated windspeed (in mph	Actual Thermometer Reading											
	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
Calm	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-67
10	40	28	16	4	-9	-24	-33	-46	-58	-70	-83	-95
15	36	22	9	-5	-18	-30	-45	-58	-72	-85	-99	-112
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	-124
25	30	16	0	-15	-29	-44	-59	-74	-88	-104	-118	-133
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109	-125	-140
35	27	11	-4	-21	-35	-51	-67	-82	-98	-113	-129	-145
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	-148
(windspeed greater than 40 mph have little additional effect	LITTLE DANGER for properly clothed. Maximum danger of false sense				INCREASING DANGER Danger from freezing of exposed flesh.				GREAT DANGER			

b. Personal clothing is required to insulate the body and is designed to allow ventilation and protectagainstheat loss. In the military the Extended Cold Weather Clothing System (EWACS) is used. EWACS consists of three layers. The inner layer is the vapor transmission layer and is porous, with numerous air pockets. The middle layer is the insulating layer which may consist of several insulating garments which minimize displacement of body-warmed, trapped air. The outer layer consists of protective wind and water resistant garment. Moisture and the mineral salts present in sweat reduce the insulating qualities of clothing. Therefore, it is important to keep the garments as clean and dry as possible. Protection of the feet is most important. Cold weather footgear uses the layering principle in black or white rubber vapor barrier (VB)boots, which are effective down to -45°F (-43°C). These boots are worn with one pair of wool cushion-soled socks. It is currently recommended that the socks be changed and dried about4times a day,although some authorities accept a daily change of socks as adequate.

c. Meteorological Data and Tactical Situations. All commanders should be familiar with simple meteorological data, such as humidity, temperature, wind, and ground surface conditions, which influence the risk of cold injury. Clothing needs and periods of exposure can thus be planned to reduce the risk of cold injury. Cold injuries will be more prevalent in fighting forces who are not in control of the tactical situation.

d. Nutrition and Activity. Normally, a calorie intake of 3500 calories per day will be adequate, but the work involved traversing snowy areas uses 4500-6000 calories per day. Carbohydrates and fats are the preferred sources for energy production. Ideally the diet should be consist of 20% protein, 45% Carbohydrates and 35% fats.

e. Water. With only light activity in the low humidity of Arctic air, a person will lose between 2 and 3 liters of water daily. Adequate intake of potable water must be ensured, and is monitored by checking the "snow flowers" or "snow spots," which are the marks made by urinating in the snow. Snow is generally contaminated by airborne dirt and animal excrement, and must not be eaten for water replacement. If snow is used, it should be boiled or iodinized properly after melting. Caffeine-containing drinks increase urine output and increase the risk of dehydration. Consuming warm liquids is desirable to protect the core temperature.

f. Training and Discipline. Acclimating to the cold for a period of 1-4 weeks is desirable, during which gradual increase in duration of exposure is accomplished, and proper physical conditioning is ensured. Personnel should be checked daily for personal hygiene, especially of the feet, and for early signs and symptoms of cold injury.

g. Susceptible Groups. Greater protection and supervision should be provided for certain groups of individuals, including the fatigue group, the racial group, the geographic origin group, the previous cold injury group, the negative group, and those with other injuries and illnesses.

5. First Aid.

Leaders of small units and groups must be familiar with the symptoms of cold injuries and illnesses and carefully observe their personnel when operating in the cold environment. Treatment of cold injury depends upon the time elapsed after injury, the severity of the injury, the presence of complications, and the area affected. The tactical situation and facilities available will also influence the treatment in military operations, where large numbers of patients may require treatment almost simultaneously. The examination and treatment of life-endangering wounds must take precedence over cold injuries. Primary treatment is divided into buddy system or first aid and initial or emergency medical treatment in forward areas.

a. First Aid or Buddy System

(1) The patient should be restricted from his or her usual duties until the severity of injury can be evaluated. A doctor should see the injury as soon as possible. All constricting items of clothing, such as boots, socks, or gloves should be removed from the site of injury. The injured area must then be protected from further cold injury by blankets and nonconstricting clothing. Smoking, drinking of alcohol, and application of salves or ointments are prohibited. Drinking of hot liquids is encouraged, if the patient is conscious and not otherwise injured or exhibiting moderate to severe hypothermia. In unusual circumstances where travel on foot is the only means of evacuation for frostbite of the feet, thawing of the injured area is not indicated until the patient reaches an aid station and medical help. Light cases of superficial frostbite may be treated by placing the injured part against the warm skin of the crotch, armpit, or abdominal skin of the patient or a buddy. Intense pain and hyperemia occur on rewarming and may persist for several hours but gradually disappear. More severe cases should be treated only at a medical facility.

(2) Hypothermic patients should be moved promptly to the battalion aid or clearing station for treatment. Mild hypothermia victims can walk on their own and speak lucidly, and can be rewarmed promptly at the battalion aid station. More serious cases must be protected from further heat loss and transported to the battalion aid station for evaluation, with transportation conducted with care to prevent ventricular fibrillation. Depending on the depth of hypothermia found to be present, moderate and severe hypothermia patients will be rewarmed at either the clearing station or a field hospital.

b. Initial or Emergency Treatment (Battalion Aid Station)

(1) Frostbite is treated by rapid rewarming in a water bath carefully controlled at 104°F (40°C), not to exceed 109°F (43°C). The water bath must have thermometer temperature control. Rapid warming should not be continued beyond the time when thawing is complete and should not be instituted if thawing has already occurred. Nonfreezing injuries should not be warmed above 98.6°F (37°C). Smoking is prohibited. Alcohol is not recommended.

Narcotics and other pain medications are not contraindicated, except where other injuries are present. All patients with cold injuries of the lower extremities are litter patients. Blisters and blebs should be ruptured if they are nonhemorrhagic but they should not be ruptured if they are hemorrhagic. The affected part should be carefully protected with loosely wrapped sterile fluff bandages during transportation. Tetanus Toxoid is administered. Prophylactic antibiotics are not recommended.

(2) Hypothermia is assessed using a low temperature thermometer, or the clinical indications of level if temperature monitoring is not possible. Individuals with hypothermia of moderate, severe, or profound levels should be protected against further temperature loss and moved carefully to a clearing station or field hospital. Only cases of mild hypothermia ((95°F to 89.6°F) (35°C to 32°C)) should be treated at the battalion aid station, because of the risk of ventricular fibrillation and other complications that may occur during rewarming. If there is any question whether victims are more than mildly hypothermic, evacuate them to the clearing station.

REFERENCES

(a) NAVMED P-5010-3, Manual of Naval Preventive Medicine, Chapter 3

(b) NAVMED P-5010-9, Manual of Naval Preventive Medicine, Chapter 9

(c) AJ-MMO-010, Preliminary Maintenance Manual Heat Stress Monitor, Model 960, Naval Sea Systems Command

(d) NIOSH Revised Criteria 1986, Criteria for a Recommended Standard, Occupational Exposure To Hot Environments, NIOSH Pub. No. 86-113.

(e) OSHA Technical Manual, OSHA Instruction CPL 2-2.20B, U.S. Department of Labor, Occupational Safety and Health Administration, Vol VI, OSHA 3058, 1989S9491

(f) Navy Environmental Health Center Technical Manual, NEHC-TM91-5, "Medical Surveillance Procedures Manual and NOHIMS Medical Matrix (Edition Four)"

(g) American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices

(h) NAVMED P-5052-29, Cold Injury

(i) NAVEDTRA 10519, Clinical Aspects of Cold Weather, Operations

Appendix A
Heat/Cold Injury Report

REPORT OF HEAT/COLD INJURY FOR NAVY/MARINE CORPS ASHORE

NEHC-TM92-6

FROM: (Reporting Activity)________________________ DATE____________

TO:
NAVY ENVIRONMENTAL HEALTH CENTER
(NEHC-32)
2510 WALMER AVENUE
NORFOLK, VA 23513-2617

NAME			
SSN			
GRADE	RATE	RACE	SEX
BIRTHPLACE			
DATE AND TIME OF EXAMINATION			
UNIT TO WHICH ATTACHED			
DATE REPORTED TO PRESENT STATION			

PRESENT ILLNESS (Onset Date and Time)	WBGT	DIAGNOSIS (Check one) ☐ HEAT CRAMPS ☐ CHILBLAIN ☐ HEAT EXHAUSTION ☐ FROSTBITE ☐ HEAT STROKE ☐ HYPOTHERMIA	TIME ON ACTIVE DUTY (Months)

DESCRIBE BRIEFLY WHAT PATIENT WAS DOING AT TIME OF INJURY INCLUDE DESCRIPTION OF CLOTHING

NOTE:
(1) ALL HEAT STRESS INJURIES SHOULD HAVE RECTAL TEMPERATURES.
(2) ALL HEAT STRESS INJURIES WITH RECTAL TEMPERATURES GREATER THAN 104° SHOULD HAVE SERUM SGOT DRAWN 24 HOURS AFTER THE INJURY.

LAB FINDINGS

SYMPTOMS (Check all applicable)

☐ UNCONSCIOUS ☐ WEAK ☐ OTHER (Specify)
☐ DIZZY ☐ NAUSEA
☐ CONFUSED ☐ CRAMPS
☐ NUMBNESS ☐ VOMITING
☐ VISUAL DISTURBANCES (Specify)

SKIN (Check all applicable)

☐ RED ☐ NORMAL
☐ PALE ☐ OTHER (Specify)
☐ WET
☐ DRY
☐ RASH

TEMP(R)	RESP.
PULSE	
HEIGHT	
WEIGHT	

HOURS OF SLEEP (Last 24 Hours)	LAST MEAL (Date and time) AMOUNT ☐ LIGHT ☐ MODERATE ☐ HEAVY	BLOOD PRESSURE SYSTOLIC________ DIASTOLIC________

AMOUNT OF WATER IN QTS. (Last 12 Hours)	SWEATING (Check one) ☐ EXCESS ☐ MODERATE ☐ NONE ☐ SLIGHT

LAST HISTORY OF HEAT/COLD ILLNESS (Specify type)

DATE (MONTH AND DAY) DIAGNOSIS NONE

RECENT ILLNESS OR IMMUNIZATION

DATE DIAGNOSIS NONE

DISPOSITION-PRESENT ILLNESS ☐ CLINIC ☐ HOSPITAL (Admitted)	☐ BINNACLE LIST/SIQ (NUMBER OF DAYS) ________	☐ LIGHT DUTY (NUMBER OF DAYS) ________

REMARKS(Initial treatment, long-term treatment potential, extent of injury, remission)

SIGNATURE PREPARED:	SUBMITTED: COMMANDING OFFICER

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COLD INJURY

HEAT INJURY